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(54) **SPRING SYSTEMS FOR VORTEX SUPPRESSION DEVICES**

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E02B 17/00 (2006.01)

F16L 1/12 (2006.01)

E21B 17/01 (2006.01)

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CPC **F16M 13/02** (2013.01); **E02B 17/0017** (2013.01); **E21B 17/01** (2013.01); **F16L 1/123** (2013.01)

(58) **Field of Classification Search**

USPC 405/211–216; 114/243; 24/271, 274 R
See application file for complete search history.

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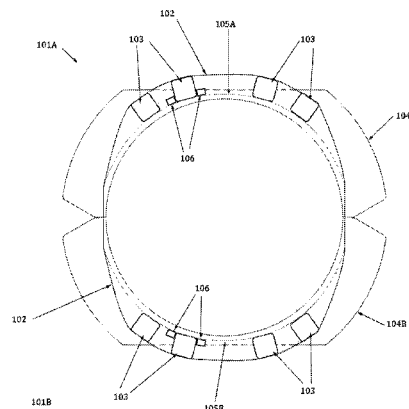
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(57) **ABSTRACT**

A vortex-induced vibration (VIV) suppression system configured to accommodate a change in an underlying tubular diameter. The system including an encircling member dimensioned to at least partially encircle an underlying tubular. The encircling member may be, for example, a collar or a VIV suppression device such as a strake, or any other type of VIV suppression device. The system further including a band member dimensioned to encircle the encircling member and hold the encircling member around the underlying tubular at a desired axial position. A spring member may further be provided. The spring member may be positioned between the encircling member and the band member and dimensioned to contract in response to an increase in a diameter of the underlying tubular and expand in response to a decrease in a diameter of the underlying tubular such that the encircling member remains at the desired axial position.

11 Claims, 10 Drawing Sheets



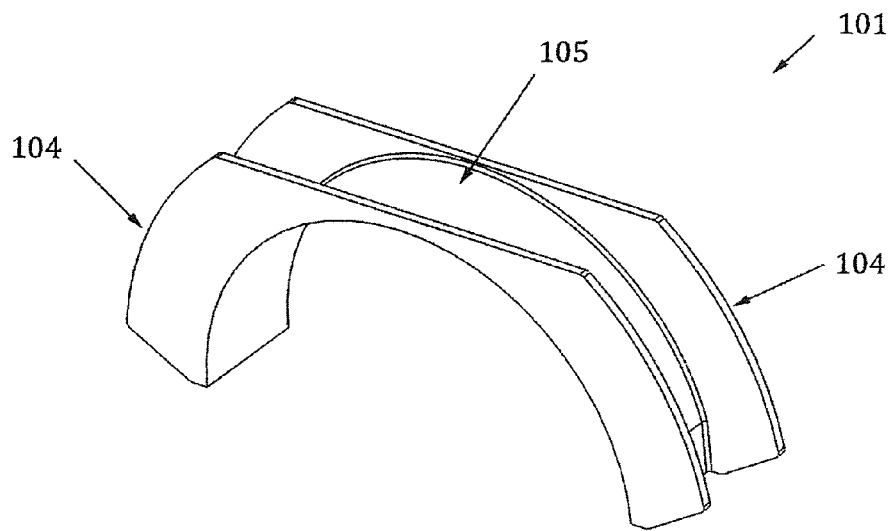


FIG. 1A

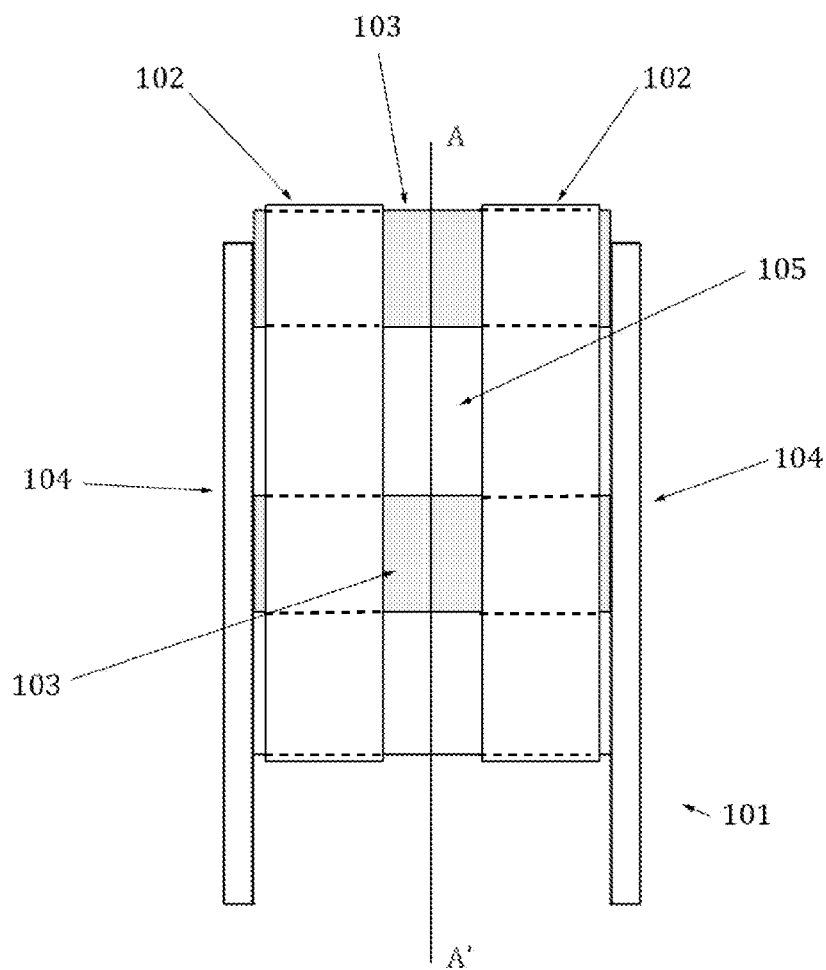


FIG. 1B

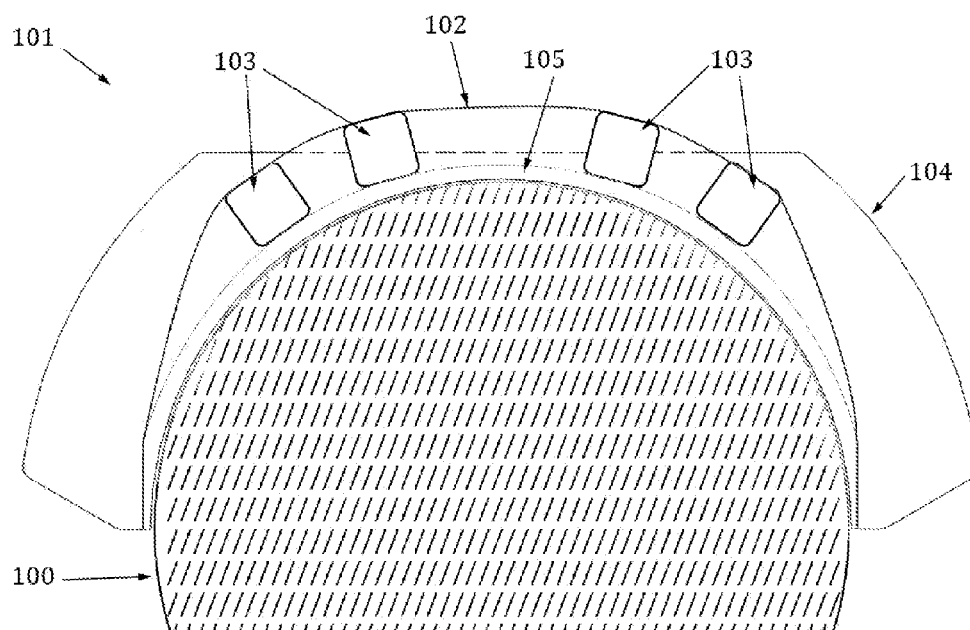


FIG. 1C

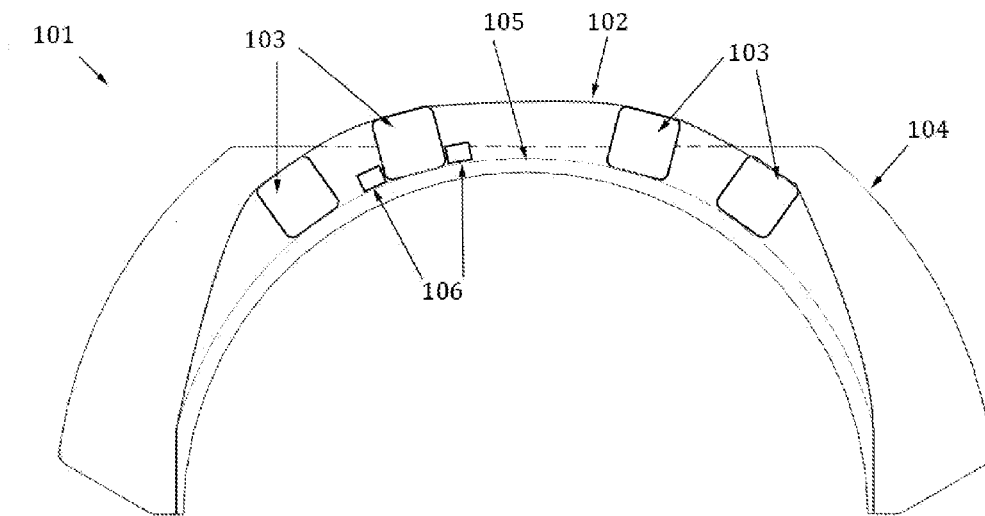


FIG. 1D

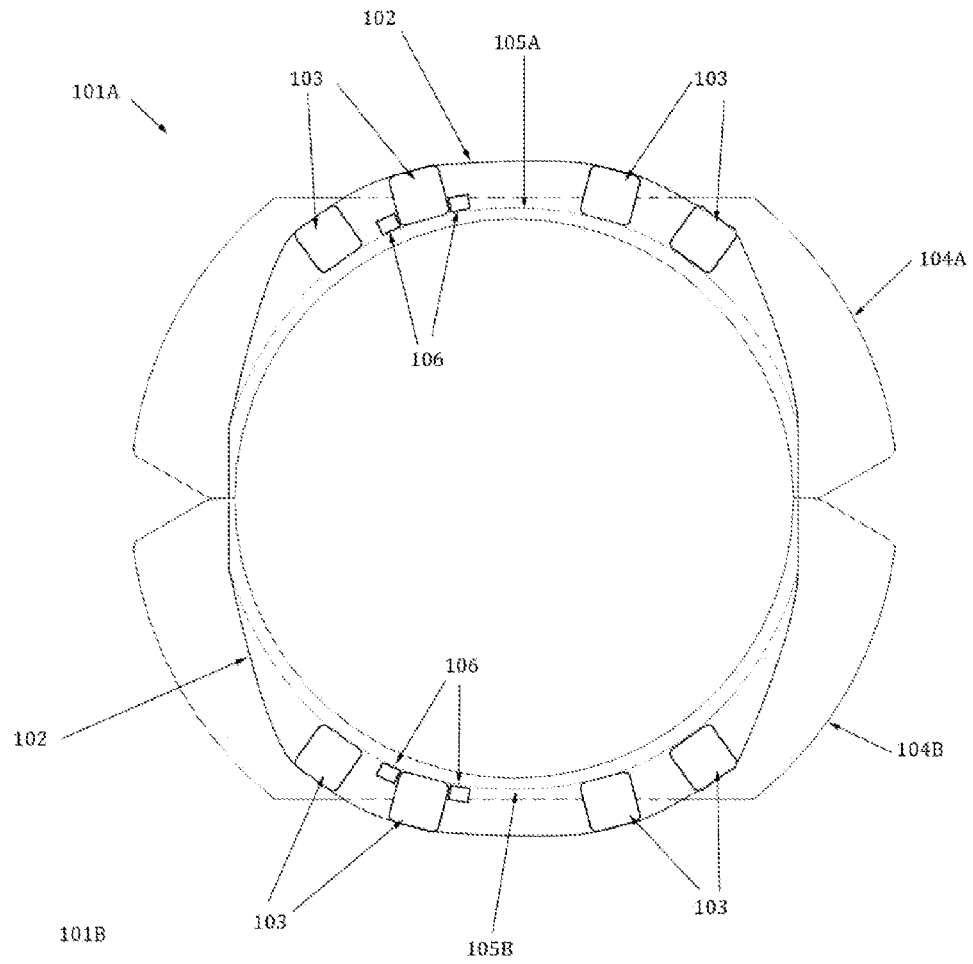


FIG. 1E

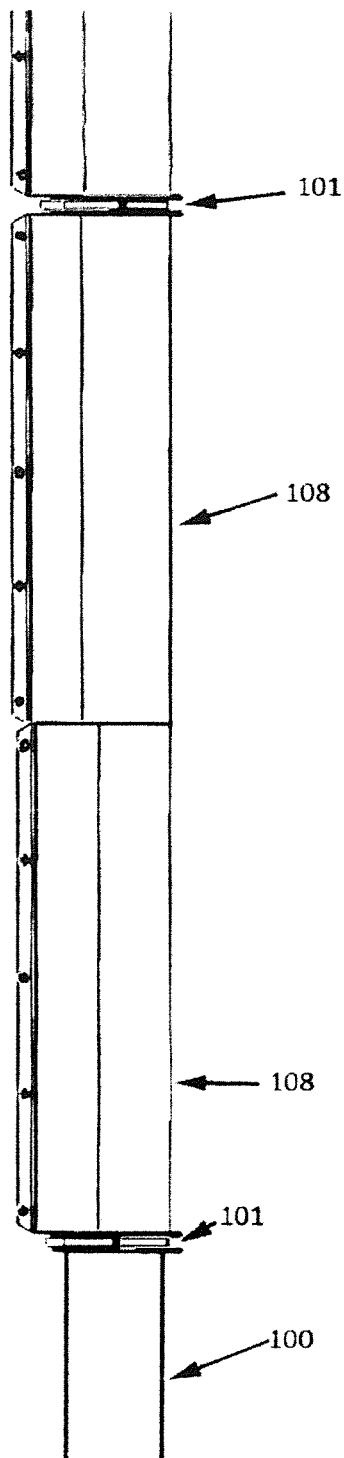


FIG. 1F

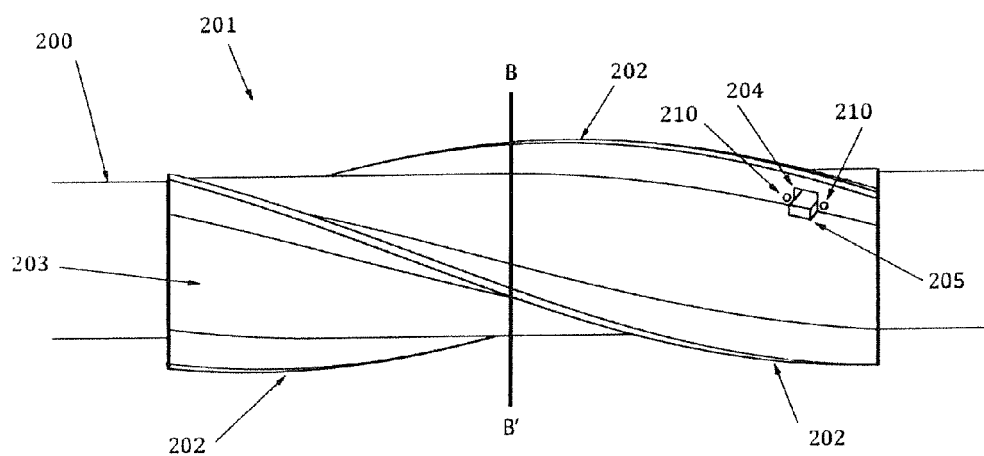


FIG. 2A

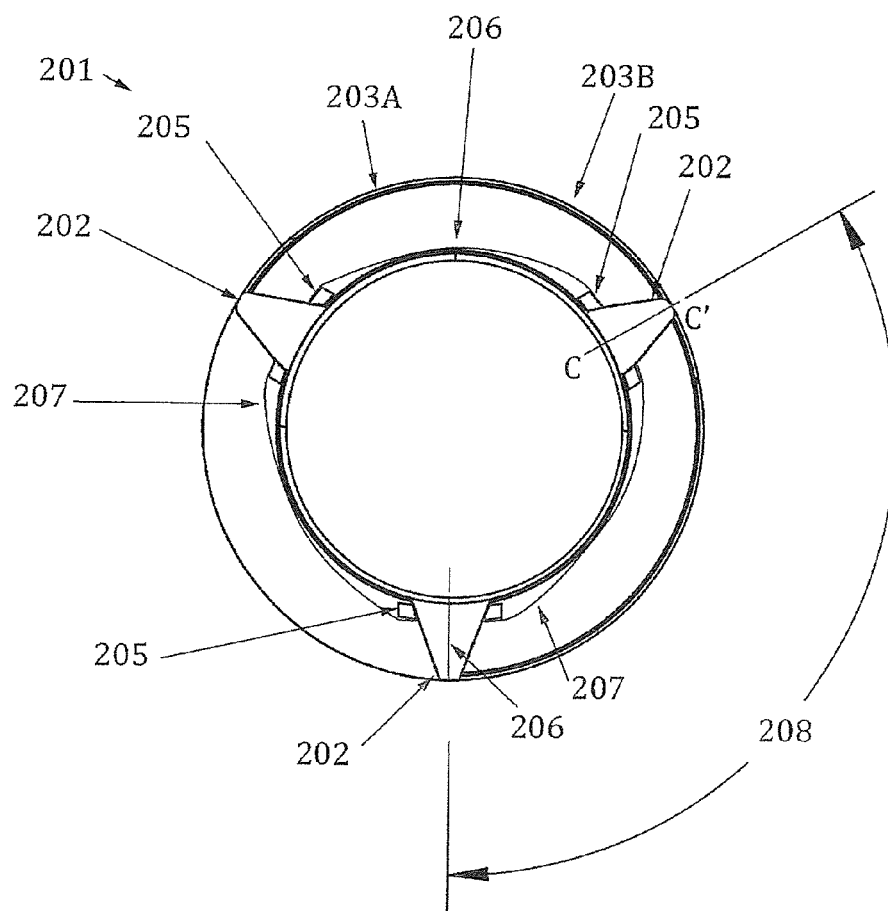


FIG. 2B

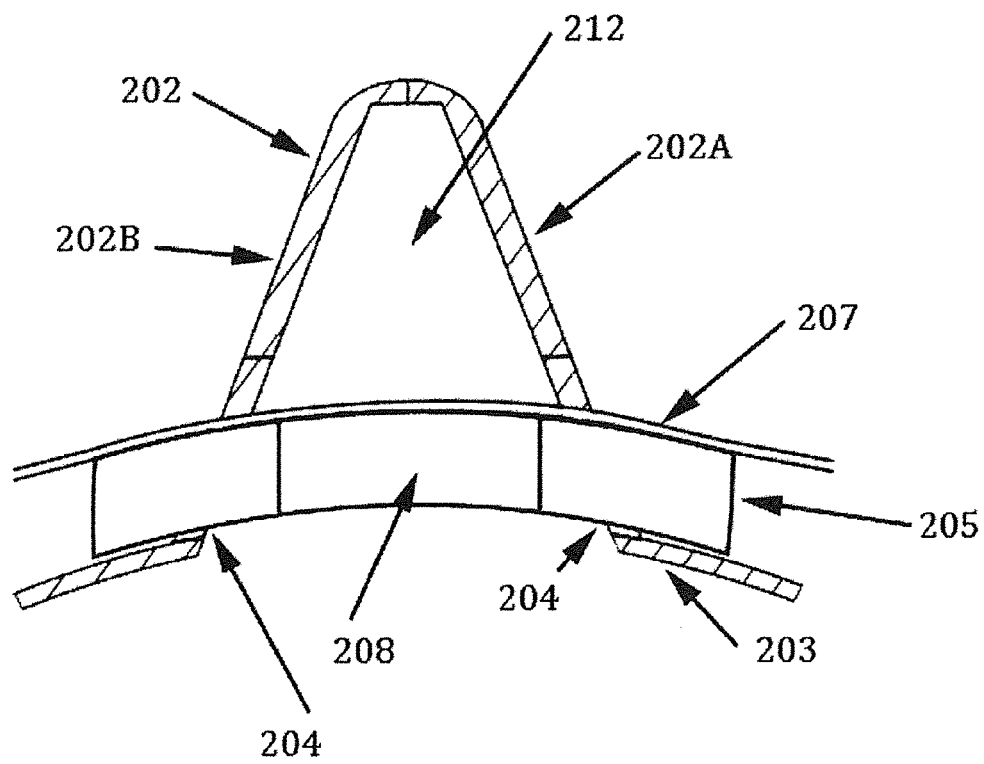


FIG. 2C

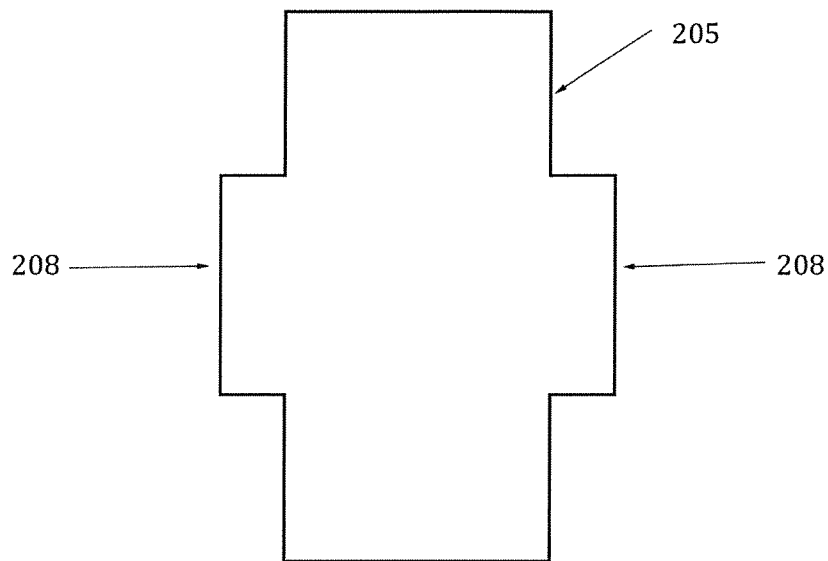


FIG. 2D

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SPRING SYSTEMS FOR VORTEX SUPPRESSION DEVICES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a divisional of co-pending U.S. patent application Ser. No. 13/829,478, filed Mar. 14, 2013, which application claims the benefit of the earlier filing date of U.S. Provisional Patent Application No. 61/711,987, filed Oct. 10, 2012, the disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

A difficult obstacle associated with the exploration and production of oil and gas is management of significant ocean currents. These currents can produce vortex-induced vibration (VIV) and/or large deflections of tubulars associated with drilling and production. VIV can cause substantial fatigue damage to the tubular or cause suspension of drilling due to increased deflections.

Two solutions for VIV suppression are helical strakes and fairings. Typically, helical strakes are made by installing fins helically around a cylindrical shell. The cylindrical shell may be separated into two halves and positioned around the tubular to helically arrange the fins around the underlying tubular. While helical strakes, if properly designed, can reduce the VIV fatigue damage rate of a tubular in an ocean current, they typically produce an increase in the drag on the tubular and hence an increase in deflection. Thus, helical strakes can be effective for solving the vibration problem at the expense of worsening the drag and deflection problem.

Another solution is to use fairings as the VIV suppression device. Typical fairings have a substantially triangular shape and work by streamlining the current flow past the tubular. A properly designed fairing can reduce both the VIV and the drag. Fairings are usually made to be free to weathervane around the tubular with changes in the ocean current.

A challenge associated with both helical strakes and fairings is their use on tubulars that have an outside diameter that shrinks due to hydrostatic pressure. This is often true of risers that have insulation or buoyancy on the outside of an inner metallic tubular. Since it is usually much cheaper to install helical strakes or fairings on a tubular while it is above the water surface (before it is lowered), this means that the tubular diameter will often be larger at the surface than at depth. Helical strakes that are banded onto the tubular risk coming loose when the diameter shrinks since the bands are typically not sufficiently compliant to accommodate the diameter change. Fairings utilize thrust collars that restrain the fairings from sliding down the tubular. These thrust collars are often banded on and suffer from the same lack of compliance that helical strakes experience.

SUMMARY OF THE INVENTION

In accordance with an embodiment of the invention, a device for supporting a vortex-induced vibration (VIV) suppression device is disclosed. The device may include a collar member having a web portion dimensioned to encircle an underlying tubular and flanges extending from opposing sides of the web portion in a direction opposite the underlying tubular. A band member may be provided which encircles the web portion and the underlying tubular so as to hold the collar member about the tubular. A resilient member may be positioned between the collar member and the web portion. The

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resilient member may be dimensioned to expand or contract in response to a change in diameter of the underlying tubular so that an axial alignment of the collar member about the underlying tubular can be maintained.

In accordance with another embodiment of the invention, a system for reducing vortex induced vibration (VIV) about a tubular is disclosed. The system may include a strake section having a shell portion dimensioned to encircle an underlying tubular and a fin extending from the shell portion. A slot may be formed through the fin portion and a band member dimensioned for insertion through the slot and around the shell portion may be provided. The system may further include a resilient member positioned within the slot portion, the resilient member dimensioned to expand or contract in response to a change in diameter of the underlying tubular so that an axial alignment of the strake section about the underlying tubular is maintained.

In accordance with another embodiment of the invention, a vortex-induced vibration (VIV) suppression system configured to accommodate a change in an underlying tubular diameter is disclosed. The system may include an encircling member dimensioned to at least partially encircle an underlying tubular. The encircling member may be, for example, a collar or a VIV suppression device such as a strake, or any other type of VIV suppression device. The system may further include a band member dimensioned to encircle the encircling member and hold the encircling member around the underlying tubular at a desired axial position. A spring member may further be provided. The spring member may be positioned between the encircling member and the band member and dimensioned to contract in response to an increase in a diameter of the underlying tubular and expand in response to a decrease in a diameter of the underlying tubular such that the encircling member remains at the desired axial position.

The above summary does not include an exhaustive list of all aspects of the present invention. It is contemplated that the invention includes all apparatuses that can be practiced from all suitable combinations of the various aspects summarized above, as well as those disclosed in the Detailed Description below and particularly pointed out in the claims filed with the application. Such combinations have particular advantages not specifically recited in the above summary.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments disclosed herein are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and they mean at least one.

FIG. 1A is a perspective view of one embodiment of a collar half.

FIG. 1B is an end view of one embodiment of a collar half with springs.

FIG. 1C is a cross sectional view of the collar half of b along line A-A'.

FIG. 1D is a cross sectional view of the collar half of FIG. 1B along line A-A'.

FIG. 1E illustrates the collar half of FIG. 1D coupled to a second collar half.

FIG. 1F illustrates a side view of one embodiment of a plurality of suppression devices supported along a tubular.

FIG. 2A is a side view of one embodiment of a helical strake on a tubular with a spring.

FIG. 2B is a cross sectional end view of the helical strake of FIG. 2A along line B-B'.

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FIG. 2C is a cross sectional view of the helical stroke of FIG. 2B along line C-C'.

FIG. 2D is a top view of one embodiment of a spring.

DETAILED DESCRIPTION OF THE INVENTION

In this section we shall explain several preferred embodiments with reference to the appended drawings. Whenever the shapes, relative positions and other aspects of the parts described in the embodiments are not clearly defined, the scope of the embodiments is not limited only to the parts shown, which are meant merely for the purpose of illustration. Also, while numerous details are set forth, it is understood that some embodiments may be practiced without these details. In other instances, well-known structures and techniques have not been shown in detail so as not to obscure the understanding of this description.

The present invention is directed to a spring system that allows a band, or other structure, used to position a VIV suppression device about a tubular to accommodate changes in the tubular outside diameter so that a position of the VIV suppression device can be maintained. In some embodiments, the spring system is a discrete spring system made up of more than one spring member that can be positioned about the band. It has been found that, in some embodiments, a discrete spring system is preferable over a system that runs most of the length of the band (e.g., a resilient liner) because such a unitary system may not be able to accommodate a significant amount of tubular shrinkage since the band pressure is low relative to the material stiffness of most practical liner materials. Even if such a spring system is hollow, it is difficult to obtain sufficient deformation of the liner so that it acts like a spring with low creep or compression set.

Referring now to the invention in more detail, FIG. 1A is a perspective view of one embodiment of a collar half. Collar half 101 may be half of a collar used to axially align a VIV suppression device about a tubular. Collar half 101 may include a web 105 and two flanges 104. Web 105 may be used as a surface to band the collar against a tubular or other structure. In this aspect, web 105 may be, for example, a band shaped member have dimensions which conform to a curvature of an underlying tubular or other structure. Flanges 104 may extend from opposing sides of web 105 in a substantially perpendicular direction (away from an underlying tubular) such that they can be used to restrict adjacent structures, such as VIV suppression devices, from sliding past collar half 101. Collar half 101 may be made of any suitable material including, but not limited to, thermoplastics, elastomers, metals, and composite or hybrid materials. Although a single collar half 101 is illustrated in FIG. 1A, it is to be understood that a complete collar includes a second collar half which is substantially identical to collar half 101 such that when the two are used together, they encircle an entire circumference of the underlying tubular.

FIG. 1B illustrates an end view of a collar half such as that illustrated in FIG. 1A. Representatively, collar half 101 is again shown having a web 105 and two flanges 104. Springs 103 are shown positioned in a widthwise direction across web 105. Springs 103 are shown positioned directly on top of web 105 such that when bands 102 are wrapped around web 105, springs 103 are between web 105 and bands 102. In this aspect, when bands 102 are tightened, they apply pressure to springs 103 which, in turn, causes springs 103 to deform. Springs 103 apply pressure to web 105, which can then apply pressure to an underlying structure (e.g., a tubular).

Still referring to FIG. 1B, web 105 will typically range from 1/2 inch wide to 12 inches wide, but most typically will

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range from 1 inch wide to 6 inches wide. A single band 102 may be used, or multiple bands 102 may be used. The bands 102 will typically range in width from 1/2 inch to 2 inches.

Springs 103 may have a finite width and may, or may not, cover the entire distance between the two flanges 104 (i.e., a width of web 105). Springs 103 may be of any suitable size, but the total of all of the springs 103 will typically cover no more than 1/2 of the total circumference of collar half 101. Springs 103 may be any type of resilient structure, for example, a hollow structure, a solid structure or made of a solid material. Springs 103 may also consist of other types of compression springs such as a coiled spring. Springs 103 may be attached to web 105 using any suitable attachment mechanism (e.g., screws, bolts, brackets, adhesives, or the like) or may be positioned on web 105 and held in place by flanges 104 and bands 102. Still further, in some embodiments, springs 103 may be molded to web 105 and/or one or both of flanges 104 by any suitable molding technique.

Still referring to FIG. 1B, collar half 101 and springs 103 may be made of any suitable material, including thermoplastics, elastomers, metals, and composite or hybrid materials. For example, springs 103 may be made of stripes of an elastomeric material.

Referring to FIG. 1C, FIG. 1C illustrates a cross-sectional side view of the collar half of FIG. 1B along line A-A' and positioned around an underlying structure. In particular, collar half 101 is shown positioned around tubular 100. Collar half 101 includes web 105 and flange 104 extending therefrom. From this view, it can be seen that springs 103 are positioned against web 104 and band 102 lies on top of springs 103. Note that it is also possible for band 102 to go through one or more springs 103. In this way, the springs may be pre-installed onto the bands.

Again referring to FIG. 1C, band 102 has a substantially fixed length such that once it is secured around collar half 101 and the underlying tubular 101, band 102 has a substantially fixed circumference. Thus, when band 102 is put into tension (such as by an expansion of tubular 101), it applies pressure to springs 103 which causes springs 103 to compress to accommodate the diameter change. Similarly, when a tension on band 102 is reduced (such as by a contracting tubular diameter), springs 103 expand to fill in the gap created between band 102 and the reduced tubular diameter so that collar half 101 is still held tightly around tubular 100.

It is noted that by having discrete springs instead of a continuous spring or liner, the local pressure on springs 103 is higher (for a given band tension) and thus the compression of springs 103 is greater. This allows collar half 101 and band 102 to accommodate a greater change in the diameter of tubular 100 than a continuous spring or liner would allow.

Still referring to FIG. 1C, web 105 may be, for example, 1/8 of an inch thick to 1 inch thick but may be of any suitable thickness. Flanges 104 may be of any suitable height. Springs 103 will be of the height and width required to accommodate the required change in diameter of tubular 100, for example from about 1/4 inch to 2 inches tall.

FIG. 1D illustrates a cross-sectional side view of the collar half of FIG. 1B along line A-A', which is substantially similar to the collar half of FIG. 1C except in this embodiment, guides are included to help hold springs in a desired position. From this view, it can be seen that collar half 101 may be substantially similar to the previously discussed collar half in that it includes web 105 and flanges 104. Springs 103 can be positioned against web 105 and band 102 lies on top of springs 103 as previously discussed. A tubular (not shown) lies underneath collar half 101. Optional guides 106 are adjacent to one of the springs 103 to keep the spring from sliding

relative to web **105**. Guides **106** may help to prevent springs **103** from sliding along web **105**.

For example, in one embodiment, guides **106** may be provided on one or more sides of spring **103** to provide resistance against sliding of springs **103**. Guides **106** may be made of a single member or multiple structural members and may be of any size and shape suitable for preventing sliding of springs **103**. For example, guides **106** may be “U” shaped brackets which extend between flanges **104** and along part of the span of springs **103**. Alternatively, guides **106** may be placed on top of springs **103**. Or guides may be placed on, or under, or around band **102**. In some embodiments, guides **106** may be fastened to collar half **101** by either fastening to web **105** or to flanges **104** by any suitable mechanism (e.g., bolts, screws, bands, brackets, adhesive or the like). In still further embodiments, guides **106** may also be fastened directly to springs **103** or to band **102**.

Guides **106** may be of any size and shape suitable for preventing sliding of springs **103** around web **105**. Representatively, in one embodiment, guides **106** may be fastener such as a bolt or screw. Guides **106** may be used to hold up any suitable spring shape. For example, guides **106** may be used to hold a helical compression spring in place. Although two guides **106** are illustrated, it is contemplated that any number of guides **106** may be used. For example, all of the springs **103** may have guides **106**, none of the springs **103** may have guides **106**, or one or more of the springs **103** may have guides **106**. Guides **106** may also be considered housings dimensioned to house an associated spring.

FIG. 1E illustrates the collar half of FIG. 1D coupled to a second collar half. Representatively, it can be seen from this view that collar halves **101A** and **101B** are held onto a tubular by band **102**. Collar halves **101A** and **102B** have webs **105A** and **105B** as well as flanges **104A** and **104B**, respectively. Springs **103** reside under band **102** and optional guides **106** restrain one or more springs **103** from sliding or overturning.

Again referring to FIG. 1E, this figure illustrates that either one or two collar halves may be used. Also, collars whose sum of all of their segments does not cover the full circumference may be used, and any number of segments may be used to make up the collar. Any number of springs **103** may also be used and any number of these springs **103** may, or may not, have one or more guides **106**. Collar halves **101A** and **101B** may be secured together around the tubular by band **102**, or/ or by other securing mechanisms (e.g., a hinge).

FIG. 1F illustrates a side view of suppression devices held in place along an underlying structure by any one or more of the previously discussed collar halves. In particular, as can be seen from this view, collar halves **101** are positioned between ends of suppression devices **108** such that they prevent suppression devices **108** from sliding axially along the underlying structure **100** (e.g., a tubular). In one embodiment, suppression devices **108** may be fairings free to weathervane around the tubular **100** while collar halves **101** are clamped around the underlying the tubular.

FIG. 1F illustrates an embodiment in which each of collar halves **101** support two suppression devices **108**. It is contemplated, however, that collar halves **101** can support any number of suppression devices **108** ranging from 1 to 100, for example where suppression devices **108** are fairings, each of collar halves **101** can support between 1 and 8 fairings. Collar halves **101** may also support other suppression devices such as helical strakes, Henning devices, splitter plate type devices, smooth sleeves, perforated structures, or any other device that requires support on a tubular.

FIG. 2A illustrates a side perspective view of one embodiment of a suppression device positioned around an underlying

structure. Representatively, FIG. 2A shows helical strake section **201** positioned around tubular **200**. Strake section **201** may have three fins **202** that are attached to, or part of, shell **203**. A slot **204** may be formed through one or more of fins **202**. A spring **205** for accommodating a tubular diameter change, such as any of those previously discussed, may be positioned within slot **204**. Optional fasteners **210** may assist in keeping spring **205** in place, either directly or by restraining an internal structure.

Helical strake section **201** may be a single piece or may consist of two or more sections around the circumference. Any number of fins **202** and/or slots **204** and/or springs **205** may be present. Each fin may or may not have one or more slots, and each slot may or may not have one or more springs. In this aspect, when a band (not shown) is placed around helical strake section **201**, through slot **204** and on top of spring **205**, spring **205** compresses as the band tightens. If a diameter of tubular **200** shrinks or otherwise changes, the spring allows the band to maintain tension even though the diameter changes. Bands may be placed on top of spring **205** or may go through spring **205**. Also, the band may reside in a channel, such as a channel to produce a gap or stand-off between the main strake body from the underlying tubular.

Spring **205** may be of any suitable shape but will typically fit into part of slot **204** and/or fins **202**. Spring **205** may be of any suitable height, and of any suitable cross section or even spring type. The helical shape of the fins **202** may sufficiently keep springs **205** in place. Optional fasteners **210** for keeping spring **205** in place may further be provided. Fasteners **210** may be any type of fastener of any size suitable for retaining spring **205** within slot **204**. For example, fasteners **210** may be bolts, screws, brackets, adhesives or the like. Helical strake section **201**, including fins **202**, shell **203**, and spring **205**, may be made of any suitable material such as those previously discussed.

FIG. 2B illustrates a cross-sectional view of the helical strake section of FIG. 2A along line B-B'. FIG. 2B shows helical strake section **201** having shell halves **203A** and **203B** which are banded together using band **207**. Shell halves **203A** and **203B** meet at a gap **206**, which may in some embodiments, extend along a length of fin **202**. Helical strake section **201** has fins **202** that are attached to shell half **203A** or shell half **203B**. Springs **205** are shown positioned through slots within each of the fins **202**. In this aspect, when band **207** is put into tension, it compresses springs **205** and puts pressure onto shell halves **203A** and **203B** which, in turn put pressure on an inner tubular (not shown). Gap **206** may get smaller as the band tension is increased.

Springs **205** may be of any suitable size, shape, material, or type such as those previously discussed, provided they are able to compress when band **207** is tightened. Springs **205** will typically each cover less than 20% of the helical strake section **201** circumference. The total of springs **205**, for a give point along the length of strake section **201**, will cover less than 50% of the circumference of strake section **201**.

FIG. 2C illustrates a cross-sectional view of the helical strake section of FIG. 2B along line C-C'. From this view, it can be seen that fin **202** includes a first portion **202A** and a second portion **202B** which extend from shell **203** such that a hollow channel **212** is formed within fin **202**. In this aspect, slot **204** is formed through both of the first portion **202A** and second portion **202B** such that spring **205** and band **207** go through both sides of fin **202**. Band **207** is positioned on top of spring **205**. In some embodiments, spring **205** may include a middle portion **208** which rests within hollow channel **212** and is dimensioned to keep the spring from slipping out through the slot. For example, middle portion **208** may extend

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out of the plane such that it is wider than slot **204**, and in some cases, is wider than opposing ends of spring **205**. In this aspect, when the tension of band **207** is increased, spring **205** compresses onto shell **203**. Spring section **208**, which is part of spring **205**, will in turn partially compress.

FIG. 2D illustrates a top view of the spring of FIG. 2C. From this view, it can be seen that spring **205** includes middle portion **208** which is wider than the rest of spring **205** and wider than the slot within which spring **205** is inserted. With middle portion **208**, spring **205** is intentionally and significantly wider than a slot that spring **205** would be inserted into. In this fashion, middle portion **208** assist in keeping spring **205** in place and from sliding through the slot and out of the slot.

Although a spring having a wider middle portion **208** is shown, it is contemplated that in other embodiments, fasteners or other appurtenances may be used in place of middle portion **208**. Middle portion **208** may be made of any suitable size, shape and material. Middle portion **208** may be part of spring **205** or middle portion **208** may be separate pieces that are bonded or attached to spring **205**.

In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes can be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. For example, while discrete springs for a collar and for a helical strake are shown, the spring system disclosed herein may be used for other structures that may be attached to a tubular such as Henning devices or measurement clamps. The discrete springs may also be used for a banded or bolted device (e.g. collar, or helical strake) by placing them between the device and the tubular. The springs may be put underneath the device so that the springs are located between the device and the tubular. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. An apparatus for supporting a vortex-induced vibration (VIV) suppression device, the apparatus comprising:
 - a collar member, the collar member having a web portion dimensioned to encircle an underlying tubular and flanges extending from opposing sides of the web portion in a direction substantially perpendicular to an underlying tubular when the collar member is positioned around an underlying tubular;
 - a band member operable to encircle the web portion and an underlying tubular when the collar member is positioned around an underlying tubular; and
 - a resilient member positioned between the band member and the web portion, the resilient member comprising a plurality of solid sections that are spaced a distance from

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one another along the web portion, and wherein the solid sections are made of a same material as the web portion and are operable to expand or contract in response to a change in diameter of an underlying tubular when the collar member is positioned around an underlying tubular.

2. The apparatus of claim 1 wherein the resilient member extends across a width dimension of the web portion and between the flanges.

3. The apparatus of claim 1 wherein the resilient member comprises an elastomeric material.

4. The apparatus of claim 1 wherein the resilient member expands in response to a reduction in the diameter of an underlying tubular around which the collar member is positioned.

5. The apparatus of claim 1 wherein the resilient member contracts in response to an increase in the diameter of an underlying tubular around which the collar member is positioned.

6. The apparatus of claim 1 wherein the band has a substantially fixed length.

7. The apparatus of claim 1 wherein the collar member is a first collar section operable to only partially encircle an underlying tubular.

8. The apparatus of claim 7 further comprising: a second collar section separate from the first collar section, wherein the first collar section and the second collar section together are configured to entirely encircle an underlying tubular.

9. The apparatus of claim 1 further comprising: a guide member positioned along at least one side of the resilient member to prevent the resilient member from sliding along the web portion.

10. The apparatus of claim 1 wherein the resilient members are molded to the collar member.

11. An apparatus for supporting a vortex-induced vibration (VIV) suppression device, the apparatus comprising:

- a collar member, the collar member having a body portion dimensioned to partially encircle an underlying tubular and flanges extending from opposing sides of the body portion, each of the flanges being one continuous structure extending between opposing ends of the collar member;
- a band member operable to encircle the body portion and an underlying tubular when the collar member is positioned around an underlying tubular; and
- a plurality of resilient members protruding from a surface of the body portion, the resilient members being solid structures that are integrally formed with, and made of a same material as, the body portion and operable to expand or contract in response to an external pressure.

* * * * *